SECTION 503 - METAL REINFORCEMENT

503.01 Description. This work shall consist of furnishing and placing reinforcing steel in accordance with these specifications and in reasonably close conformity with the plans or as directed.

Separate bids may be taken on "Metal Reinforcement, Schedule No. 1" which shall cover the metal reinforcement placed in substructures, and "Metal Reinforcement, Schedule No. 2" which shall cover the metal reinforcement placed in superstructures. The schedule will be shown on the plans for the structures involved.

503.02 Materials. Materials shall meet the requirements specified in the following Subsections of Section 700 - Materials:

Reinforcing Steel	708.02
Epoxy Coated Metal Reinforcement	708.02
Dowel Bars	708.03
Tie Bars	708.04

Each shipment of reinforcing steel delivered to the project shall be accompanied by a completed ITD-914 with a copy of the mill test report attached for each heat included in the shipment. Field samples will be taken by the State for each heat number and bar size from material delivered to the project. The supplier must submit proper identification with each shipment delivered to a project worksite to allow the State to readily identify each bar size by heat number. Reinforcing steel delivered that cannot be identified by heat number shall be rejected and replaced by the supplier at no cost to the State.

The Contractor shall order additional bars to compensate for the field sampling. Additional sampling of the replacement bars is not required. Cutting and splicing to obtain samples is not permitted. Complete fabricated bars are to be sampled and replaced. If bar configuration is such that two 36 in. (900 mm) long test specimens can be cut from one bar, then only one such bar constitutes a field sample. Otherwise, two complete fabricated bars constitute a single field sample.

Reinforcing steel spirals shall be fabricated with additional length to accommodate sampling. No cutting that would require splicing will be permitted to obtain samples.

All bar from failing heat numbers shall be rejected and replaced by the Contractor at no additional cost to the State.

503.03 Construction Requirements.

A. *Bar List and Bending Schedule.* The bar list and bending schedule are made for the purpose of arriving at an estimate of quantities. The Contractor shall verify the quantity,

size and shape of the bar reinforcement against the structure drawings and make any necessary corrections before ordering. Errors in the bar list and bending schedule shall not be cause for adjustment of contract unit price.

B. *Protection of Material.* Steel reinforcement shall be protected at all times from damage. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil, or other foreign substance. Epoxy-coated reinforcing steel shall not be stored outdoors by the contractor for more than two months. When stored outdoors, such bars shall be covered for protection against the elements and in such a manner that condensation does not form on the bars.

C. *Bending.* Field bending of reinforcing bars shall be performed only on bars conflicting with pre-stressing ducts, within anchorage recesses and as shown on plans or approved by the Engineer.

Field bending shall not be done:

1. On bar sizes larger than No.7 (No.22), unless approved;

2. When the application of heat is required and the ambient temperature is lower than 50°F (10°C) and wind velocity at the bending site exceeds 15 mph (25 km/h);

3. By using torch tips designed for flame cutting, when heat application is required;

4. By means of hammer blows or other impact loading.

When field bending steel reinforcing bars, the Contractor shall:

1. Make the bend gradually;

2. Apply heat as described in these specifications in bending bars sizes No.6 and No.7 (No.19 and No.22) or in bending bar sizes No.5 (No.16) and smaller when those bars have been previously bent. Previously unbent bar of sizes No.5 (No.16) and smaller may be bent without heating;

3. Use a bending tool equipped with a Bend Inside Diameter / Bar Diameter ratio of 8.

4. Limit any bend to a maximum of 90 degrees;

5. Straighten by moving a hickey bar (if used) progressively around the bend.

In applying heat for field bending steel reinforcing bars, the Contractor shall:

1. Use only rosebud type torch tips, designed to give a diffused flame;

2. Insulate any concrete within 6 in. (150 mm) of the heated bar area;

3. Ensure by means of temperature indicating crayons or other suitable means that the steel temperature at the end of a heating operation will be as follows:

   1200°F to 1250°F (650°C to 675°C) for bar size No.4 (No.13)

   1350°F to 1400°F (730°C to 760°C) for bar sizes No. 5 and No. 6 (No.16 and No.19)

   1400°F to 1445°F (760°C to 785°C) for bar size No.7 (No.22);

4. Heat the entire length of the bend plus a 2 in. (50 mm) additional length on each side of the bend;

5. Maintain the steel temperature within the required range shown above during the entire bending process;

6. Bend the bar immediately after the required temperature has been reached;

7. Never cool bars artificially with water, forced air, by placing them on the ground or a concrete floor or other means.

8. Transport or install hot, bent bars after they have reached the ambient temperature.

Prior to bending bars in the field, the Contractor shall submit for approval a Field Bending Plan describing the proposed methods, tools, materials and handling of the field bent reinforcement, in accordance with these specifications.

D. *Placing and Fastening.* During the placing of concrete, reinforcing steel shall be firmly held in the position shown on the plans. Reinforcement position shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. The supports for metal reinforcement shall not be spaced more than 4 ft. (1.2m) apart transversally or longitudinally. If concrete blocks are used, they shall have appropriate tie wires or coated tie wires embedded in them during their forming stage and each block shall be tied to the reinforcing bar it supports to hold the block in place. Concrete blocks shall have approximately the same strength quality as the concrete placed around them. Plastic coated tie wire and plastic coated metal bar supports shall be required whenever they will be in direct contact with epoxy coated reinforcing. The use of

pebbles, pieces of broken stone, broken concrete, metal pipe or wooden blocks will not be permitted. Additionally, top layers or mats of metal reinforcement in bridge decks shall be tied down to stirrups, shear studs, or in another approved manner, with such tiedowns located so that there is at least one tiedown per 16 SF (1.5 m^2) of deck surface; these tiedowns shall be of sufficient strength to prevent upward movement of reinforcement from any cause. Concrete deck reinforcing steel shall not deviate more than ±0.25 in. (±6 mm) in the vertical direction from the position shown on the plans.

Reinforcement in any member shall be placed and inspected before concrete is placed. Before any concrete is placed, all damage to epoxy coating of reinforcing steel, occurring during installation shall be repaired. Remove rust and contaminants from the steel surface and adjacent coating, by wire brushing immediately before applying patching material. Use a patching material certified to meet AASHTO M284, and apply it in accordance with the manufacture's recommendations.

Reinforcing bars shall be tied at all intersections unless spacing is less than 1 ft. (300 mm) in each direction, when alternate intersections shall be tied. Where bundled bars are shown on plans, bundles shall be tightly tied at intervals not exceeding 3 ft. (1 m) with No.16 (1.42 mm) black or plastic coated steel wire or larger. Except for precast items, welding of reinforcing steel is only permitted where shown on plans, or with written approval. Such welding shall, with the same exception, conform to AWS D1.4 “Structural Welding Code - Reinforcing Steel.”

Reinforcing steel assemblies for pre-cast items may be welded instead of tied, subject to the conditions of this paragraph. Weld location shall be indicated on shop drawings. Welding is not permitted at the casting bed when any pre-stress reinforcement is present on the bed. Any design bars shown on project plans may be tack welded to extra No.4 (No. 13) bars for positioning. Such tack welds shall not exceed 1 in. (25 mm) length, and shall be located only at the very ends of design bars. The extra bars shall be shown on shop drawings and identified as bars whose only function is to position the design bars. Such extra bars are subject to the same concrete cover requirement as design bars, and shall be located so as not to interfere with pre-stress reinforcement or other design details. These positioning bars may be welded to each other. If epoxy coated bars are specified, the positioning bars must also be coated. In addition, all welds and weld-damaged coating must be cleaned by wire brush and coated with a patching compound recommended by the epoxy supplier.

E. *Splices*. Reinforcement shall be furnished in the full length indicated on the plans except for column spirals. No splicing of bars, except where shown on the plans and in the column spirals, will be permitted without written approval of the Engineer. The bars shall be rigidly clamped or wired at all splices in an approved manner.

No field splices of column spirals shall be permitted in the lower one-fourth or the upper one-fourth of the spiral. Welded splices in column spirals shall conform to the current edition of AWS D1.4 and shall meet the carbon equivalent requirements. Field splices in column spirals shall be by mechanical splices.

At locations where mechanical splices are required on the plans, the Contractor shall form mechanical splices for epoxy and non-epoxy coated bars with an Engineer-approved system, using mechanical couplers or other approved method that complies with this section. No welded splices will be allowed. All exposed components of the splice used for the epoxy-coated bars shall be epoxy-coated or protected from corrosion by other approved means.

Before splicing, the Contractor shall provide the Engineer with the following information for each shipment of splice material:

1. The type of series identification (and heat treatment lot number for threaded-sleeve splices).

2. The grade and size of the bar to be spliced.

3. A manufacturer's catalog with complete data on material and procedures.

4. A written statement from the Contractor that the system and materials will be used according to the manufacturer's instruction and all requirements of this section.

One tension test specimen splice shall be made to represent each lot of bars spliced in the field. A lot shall consist of every 50 epoxy coated or every 50 non-epoxy coated bars spliced in the field, of one size, by one operator. Each specimen shall be tensioned to destruction or to the specified ultimate strength, whichever is less. The Contractor shall perform tests in a qualified laboratory. Reports shall be promptly furnished to the Engineer. If any test specimen fails to meet the tensile strength requirements, two production splices from the lot represented by the specimen shall be cut out and tested by the Contractor. If both retests meet tensile requirements, all splices in the lot will be accepted. If one or both retests fail to meet the requirements, all splices in the lot will be rejected. All costs of removal, testing, and replacing shall be borne by the Contractor.

All mechanical splices shall meet the following criteria:

1. All splices shall develop at least 125 percent of the yield tensile strength specified for the unspliced bar. The ultimate tensile strength of the sleeve shall exceed that of the other parts of the completed splice.

2. AASHTO M 31 (M 31M) bars within a splice sleeve shall not slip more than 0.045 in. (1.1 mm) for Grade 60 (420) bars. The slippage shall be measured between gage points clear of the splice sleeve. Measurements shall be taken at initial load of 3000 psi (20.68 Mpa) and again after loading to 90 percent of the minimum specified yield strength for the unspliced bar and then relaxed to 3000 psi (20.68 Mpa).

Compensation. No separate compensation will be allowed for the cost of furnishing and installing mechanical splices, nor for their testing where required. All costs shall be considered subsidiary to the bid item for metal reinforcement.

503.04 Method of Measurement. Except as indicated elsewhere in the specifications, metal reinforcement will be measured by the pound (kilogram), based on the theoretical pound (kilogram) complete in place as shown on the plans or placed as ordered.

Epoxy coated metal reinforcement will be measured by the pound (kilogram) of reinforcing steel prior to coating, based on theoretical pound (kilogram) complete in place as shown on the plans or placed as ordered.

503.05 Basis of Payment. Except as indicated elsewhere in the specifications, the accepted quantities of Metal Reinforcement will be paid for at the contract price per pound (kilogram) complete in place. No allowance will be made for clips, wire, or other material used for fastening reinforcement in place.

The weight of the splice bars will be included in the weight for which payment is made if the splice bars are shown on the plans or ordered installed. No payment will be made for bars installed for the Contractor's convenience.

Payment for Schedule 2 Metal Reinforcement will be made on “plan quantities” as specified in Subsection 109.01. The accepted quantities of epoxy coated metal reinforcement will be paid for at the contract unit price per pound (kilogram) of steel. No allowance will be made for plastic coated wires, supports or other material used for fastening epoxy coated reinforcement in place.

Payment for acceptable work will be made as follows:

Pay Item	**Pay Unit**
Metal Reinforcement	lb. (kg)
Metal Reinforcement, Schedule No. ____	lb. (kg)
Epoxy Coated Metal Reinforcement	lb. (kg)

SECTION 504 - STRUCTURAL METALS

504.01 Description.

A. *General*. This work shall consist of furnishing, fabricating, erecting and painting structural metals in accordance with these Specifications, the Special Provisions and the details shown on the plans or as directed.

B. *Fabricator Certification.* Fabricators of structural components for all vehicular bridges, other than unspliced rolled beam bridges, shall be certified under the AISC Quality Certification Program, Major Steel Bridges category. Fabricators of structural components for all unspliced rolled beam vehicular bridges and steel pedestrian bridges, shall be certified under the AISC Quality Certification Program, Simple Steel Bridge Structures category. This requirement does not apply to incidental sub-assemblies such as drainage components, expansion joints, handrails, lighting supports, or items of similar nature.

C. *Notice of Rolling and Fabrication.* The Contractor shall give ample notice to the Engineer of the beginning of the work at the mill or shop so that inspection may be provided. No material shall be manufactured, or work done in the shop, before the Engineer has been so notified.

D. *Inspection.* Structural steel will be inspected at the fabrication site. The Contractor shall furnish four copies of all mill orders, certified mill test reports and shipping statements. Mill test reports shall show the chemical analysis and physical test results for each heat of steel used in the work.

With the approval of the Engineer, certificates of compliance shall be furnished in lieu of mill test reports for material that normally is not supplied with mill test reports, and for some items such as fills, minor gusset plates and similar material when quantities are small and the material is taken from stock.

Certified mill test reports for steels with specified impact values shall include, in addition to other test results, the results of Charpy V-notch impact tests. When fine grain practice is specified, the test report shall confirm that the material was so produced. Copies of mill orders shall be furnished at the time orders are placed with the manufacturer. Certified mill test reports and Certificates of Compliance shall be furnished prior to the start of fabrication of material covered by these reports. The Certificate of Compliance shall be signed by the manufacturer and shall certify that the material is in conformance with the specifications to which it has been manufactured.

Material to be used shall be made available to the Engineer so that each piece can be examined. The Engineer shall have safe and free access at all times to any

portion of the fabrication site where the material is stored or where work on the material is being performed.

E. *Quality Control Inspection.* Quality control inspection and testing shall be the responsibility of the Contractor. The Contractor shall perform inspection and testing at least to the extent specified and in accordance with the ANSI/ AASHTO/ AWS D1.5 Bridge Welding Code, Section 6 - Inspection.

Nondestructive testing in addition to visual inspection, testing to base metal, production welds, weld repairs, procedure qualification test weldments and welder, welding operator and tacker qualification test weldments are included. Cost of nondestructive testing shall be considered incidental to the structural steel fabrication/erection and no separate payment will be made. The Contractor shall provide all facilities the Inspector requires to inspect material and workmanship.

F. *Inspector's Authority.* The Inspector may reject materials or workmanship that does not comply with these specifications. In any dispute, the Contractor may appeal to the Engineer whose decision shall be final.

By its inspection at the mill and shop, the state intends to facilitate the work and prevent errors. This inspection shall not relieve the Contractor of any responsibility for identifying and replacing defective material or workmanship.

Even if the Inspector accepts material or finished members, the state may later reject them if defective. The Contractor shall promptly replace or make good any rejected materials or workmanship.

G. *Shop Plans.* The Contractor shall submit for approval all shop detail plans for fabricating the steel. Unless otherwise directed by the Engineer, these shall be sent to the Bridge Design Engineer, Idaho Transportation Department, 3311 West State Street, P.O. Box 7129, Boise, ID 83707.

When the plans are submitted directly to the Bridge Design Engineer, a copy of the transmittal letter shall be sent to the Resident Engineer.

Six sets of the plans shall be supplied to the Bridge Design Engineer (four more sets are required for each affected railroad company on any grade separation structure that carries a railroad over a highway).

In approving shop plans, the state accepts only the nature and scope of the details without validating any dimensions.

Unless the Engineer permits it in writing, no changes shall be made in any drawing after its approval.

Before project completion, the Contractor shall furnish the Engineer one set of reproducible copies of the as-built shop plans. (One more set is required for each affected railroad company on any grade separation structure that carries a railroad over a highway.) The reproducible copies shall be clear, suitable for microfilming, and on permanent material.

Working drawings shall be 22 in. × 34 in. (559 mm × 864 mm) in size and each drawing and calculation sheet shall include the job site name of the structure as shown on the contract plans, District-County-Route, bridge number, contract number, and contract drawing number.

Welding procedures shall be submitted for approval with shop drawings. The procedures shall specify the type of equipment to be used, electrode selection, preheat requirements, base materials, and joint details. When the procedures are not prequalified by AWS or AASHTO, evidence of qualification tests shall be submitted.

H. *Erection Plans.* The Contractor shall submit the proposed method for erection to the Engineer for approval. The erection procedure shall be reviewed by the steel fabricator prior to being submitted to the Engineer.

The Contractor shall include in the submittal calculations of the maximum stresses that each member will be subjected to during erection. These calculations will determine the necessity of using strongbacks or erecting the girders in pairs with cross frames installed to prevent the possibility of buckling the compression flange during erection of the girders. The calculation shall be stamped by a registered professional engineer. Any falsework or temporary structures shall meet the requirements of Section 502.03 , Part E-*Falsework and Forms.*

Falsework and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within 6 in. (150 mm) of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral and/or eccentric loads applied to the girders and to prevent appreciable relative vertical movement between the edge of deck form and the adjacent steel girder.

The erection procedure shall be supplemented with any necessary drawings to clearly describe the method proposed. The plan shall show details of all falsework bents, bracing, guys, temporary anchors, lifting devices, attachments to the bridge members, sequence of erection, location of lifting points on the bridge members, and weights of the members. The plan and drawings shall be complete in detail for all anticipated phases and conditions during erection.

The Contractor shall also submit complete plans of any temporary members or devices which affect stresses in the permanent members of the structure. All temporary or extra material required shall be removed and no payment shall be made for any extra material required due to the Contractor's erection procedures or method. In addition, no measurement or payment will be made for any material required in the permanent structure due to the Contractor's erection scheme.

Approval of the Contractor's erection plans, falsework, temporary material and equipment shall not be considered as relieving the Contractor of his full responsibility for the practicability and safety of the erection schemes used or for carrying out the work in full accordance with the plans and specifications.

Any material ordered or shop drawings prepared prior to the review of the erection scheme by the Engineer shall be the responsibility of the Contractor.

The plan and drawings shall be submitted for approval as prescribed in Section 502.03 *Falsework and Forms.*

I. *Camber Diagram.* A camber diagram shall be furnished to the Engineer by the fabricator, showing the camber at each panel point in the cases of trusses or arch ribs, and at the location of field splices and tenth points of span length in the cases of continuous beam and girder or rigid frames. The camber diagram shall show calculated cambers to be used in preassembly of field connections.

504.02 Materials

A. *Structural Metals.* Materials shall meet the requirements of the plans and Subsection 708.06-Structural Steel and Related Materials.

For all members identified on the plans as "Fracture Critical Member(s)," the additional fabrication, inspection and certificate requirements of the current AASHTO Guide Specifications for Fracture Critical Non-redundant Steel Bridge Members and current Interim Specifications shall apply.

Universal mill plates shall not be used for flange plates in designated tension stress or stress reversal areas.

Structural steel shall be classified as:

Structural carbon steel (to be used whenever the plans do not specify another classification), AASHTO M 270, Grade 36 (M 270M, Grade 250).

Structural low alloy steel, AASHTO M 270, Grade 50 and 50W (M 270M, Grade 345 and 345W).

Structural high strength steel, AASHTO M 270 Grade 485 (M 270M, Grade 485W).

Unless the Plans or Special Provisions state otherwise, the following shall be classified as structural carbon steel:

Shims; ladders; stairways; anchor bolts and sleeves; pipe fittings and fastening used in handrails; and other metal parts, even if made of other materials, for which payment is not specified.

B. *Painting.* When required on the plans the structural steel shall be painted in conformance with Section 627 Painting. Paint shall meet the requirements of Section 707 - Paint.

C. *Handling, Storing, and Shipping of Materials.* Markings applied at the mill shall distinguish structural low alloy steel from structural carbon steel. The fabricator shall keep the two classes of steel carefully separated.

Before fabrication, all material stored at the fabricating plant shall be protected from rust, dirt, oil, and other foreign matter. The state will not accept rust-pitted material.

After fabrication, all material awaiting shipment shall be subject to the same storage requirements as unfabricated material.

All structural steel shall arrive at the job in good condition. As the Engineer requires, steel damage by saltwater shipment shall be thoroughly cleaned by high pressure water flushing, chemical cleaning or sandblasting, and repainted with the specified shop coat.

All material shall be stored so as to prevent rust and loss of small parts. Piled material shall not rest on the ground or in water but on skids or platforms.

The loading, transporting, unloading, and piling of the structural steel material shall be so conducted that the metal will be kept clean and free from injury from rough handling.

After fabrication, girders and beams shall remain upright during shipment, handling and storage unless otherwise approved in writing by the Engineer. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.

In field assembly of structural parts, the Contractor shall use methods and equipment not likely to twist, bend, deform, or otherwise injure the metal. Any member slightly

bent or twisted shall be corrected before it is placed. The state will reject any member with serious handling damage.

Scratches and gouge marks caused by handling and lifting, and located in tension or stress reversal regions, shall be repaired. Repair shall consist of grinding to a surface finish of ANSI 125 or better and inspecting by the dye penetrant or magnetic particle method. If such marks are located in an area where they will be covered or partly covered by a structural weld, the grinding and testing shall be done before welding.

Girder sections shall be handled so as to prevent damage to the girders. Girders shall be laterally supported during shipment by blocking, removable flange bracing, bolting in pairs, or other approved method. The method of lateral support for the girders shall be shown on the shop drawings.

Members weighing more than 6000 lb. (2700 kg) shall have the weight marked thereon and removed after erection is completed.

D. *Castings.* This section's requirements for structural steel (including painting requirements) shall also apply to castings.

Castings shall be:

1. True to pattern in form and dimensions;

2. Free from pouring faults, sponginess, cracks, blow holes, and other defects in places that would affect strength, appearance, or value;

3. Clean and uniform in appearance;

4. Filleted boldly at angles; and

5. Formed with sharp and perfect arises.

Iron and steel castings and forgings shall be annealed before any matching, unless the plans state otherwise.

504.03 Construction Requirements.

A. *Identification of Steels During Fabrication.* The Contractor shall submit for the Engineer's approval a written plan for visibly marking the material so that it can be traced. These marks shall remain visible at least through the fit-up of the main load-carrying tension members. The marking method shall permit the Engineer to verify:

1. material specification designation;

2. heat number; and

3. material test reports to meet any special requirements.

For steel in main load-carrying tension members and in tension components of flexural members, the Contractor shall include the heat numbers on the reproducible copies of the as-built shop plans.

B. *Edge Finishing.* All rolled, sheared, and flame cut edges shall be true to line and free of rough corners and projections. Corners along exposed edges shall be rounded to a radius of 1/16 in. (2 mm) or greater. Sheared edges on material more than 5/8 in. (16 mm) thick shall be planed, milled, ground or thermal cut to a depth of 1/4 in. (6 mm).

Surface roughness of flange plates in designated tension stress or stress reversal areas (rolled, sheared, and flame cut edges) shall not exceed 250 μ in. (6 μm) as defined by ANSI specifications. On flame cut edges, this roughness may be obtained after cutting by grinding or other approved means.

Surface roughness of other rolled, sheared and flame cut edges shall not exceed 1,000 μ in (25 μm), unless otherwise specified on the plans.

C. *Thermal Cutting.* The Contractor shall take steps to insure that the flame cut edges of main material are not hardened by the cutting process. This may be achieved by preheating, post heating or control of the burning process. Edge hardness for AASHTO M270M, Grade 345 and 345W plates after flame cutting found to have a Rockwell Hardness Value of C30 or greater will be considered unacceptable. Hardness shall be determined by AASHTO T 80. Plate edges shall be tested at least once for each fabrication piece or as directed by the Engineer. Unacceptably hard surfaces shall be removed by approved grinding, machining, or approved heat treating procedures.

Flame cutting procedures for AASHTO M 270M, Grade 345/345W, and 690/690W, or other high strength low alloy steels shall include preheating to the following temperatures:

Thickness (t) of Thickest Part at Point of Cutting, in. (mm)		**Temperature** °**F**	(°**C**)
$t \leq 0.75$	$(t \leq 19)$	50	(10)
$0.75 < t \leq 1.5$	$(19 < t \leq 38)$	70	(21)

$1.5 < t \leq 2.5$	$(38 < t \leq 63.5)$	149	(65)
$t > 2.5$	$(t > 63.5)$	225	(107)

The plate shall be preheated in such a manner that the required temperature is obtained through the full thickness of the plate ahead of and laterally from the cut a distance of 3 in. (75 mm) or the plate thickness, whichever is greater.

Preheat temperatures shall be shown on the shop drawings.

D. *Fit and Bearing.* Ends of columns that bear on base and cap plates shall be milled to true surfaces and accurate bevels.

When assembled, caps and base plates of columns and the sole plates of girders and trusses shall have full contact. If warped or deformed, the plates shall be heat straightened, planed, or corrected in some other way to produce accurate, even contact. If necessary for proper contact, bearing surfaces that will contact other metal surfaces shall be planed or milled. Surfaces of warped or deformed base and sole plates that will contact masonry shall be rough finished.

On the surface of expansion bearings, the cut of the planer shall be in the direction of expansion.

Abutting ends of compression members shall be faced accurately so that they bear evenly when in the structure. On built-up members, the end shall be faced or milled after fabrication.

Ends of tension members at splices shall be rough finished to produce neat, close joints. A contact fit is not required.

Floor beams, stringers, and girders having end connection angles shall be flush with each other and set accurately in relationship to the position and length of the member. Unless the plans require it, end connection angles shall not be finished. If, however, faulty assembly requires them to be milled, milling shall not reduce thickness by more than 1/16 in. (2 mm).

The various pieces forming one built member shall be straight and close-fitting, true to detailed dimensions, and free from twists, bends, open joints, or other defects.

For field-bolted splices, the clearance between web plates shall not exceed 3/8 in. (10 mm).

Bearing stiffeners shall be milled to bear so that they will bear evenly against the flange. Intermediate stiffeners shall fit tightly enough to exclude water after painting.

E. *Grinding.* All plates shall be ground so that the direction of grinding is parallel with the direction of tensile or compressive stress; the direction of grinding shall be shown on the shop plans.

F. *Camber.* Cambering in the plane parallel to the strong axis of the girder shall not be done by the use of heat or mechanical bending. For plate girders, the web shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving.

G. *Curvature.* Girder curvature in an axis parallel to the girder web as shown in the plans shall be produced by fabrication methods that follow AASHTO Specifications for Highway Bridges, Division II-Construction, or as approved by the Engineer.

H. *Pins and Rollers.* Pins and rollers shall be made of the class of forged steel the plans specify. They shall be turned accurately to detailed dimensions, smooth, straight, and flawless. The final surface shall be produced by a finishing cut.

Pins and rollers more than 9 in. (225 mm) in diameter shall be forged and annealed. Pins and rollers 9 in. (225 mm) or less in diameter may be either forged and annealed or cold finished carbon steel shafting.

In pins larger than 9 in. (225 mm) in diameter, a hole not less than 2 in. (50 mm) in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range and before being annealed. Such cooling shall be done under conditions which will prevent injury by cooling too rapidly.

Pin holes shall be bored true to detailed dimensions, smooth and straight, and at tight angles to the axis of the member. Holes shall be parallel with each other unless the plans state otherwise. A finishing cut shall always be made.

The distance between holes shall not vary from detailed dimensions by more than 1/32 in. (1 mm). In tension members, this distance shall be measured from outside to outside of holes; in compression members, inside to inside.

Each pin shall be 1/50 in. (0.5 mm) smaller in diameter than its hole. All pins shall be numbered after being fitted into their holes in the assembled member. All pins shall be magnetic particle tested in accordance with ASTM A275 by an independent testing laboratory. Pins with inner defects will be rejected.

The Contractor shall provide two pilot and two driving nuts for each size of pin unless the plans state otherwise.

I. *Machine Finished Surfaces.* As soon as possible and before they leave the shop,

machine-finished surfaces on abutting chord splices, column splices, and column bases shall be covered with grease. After erection, the steel shall be cleaned and painted as specified.

All surfaces of iron and steel castings milled to smooth the surface shall be painted with the primer called for in the specified paint system.

While still in the shop, machine-finished surfaces and inaccessible surfaces of rocker or pin-type bearings shall receive the full paint system. Surfaces of pins and holes machine-finished to specific tolerances shall not be painted. But as soon as possible and before they leave the shop, they shall be coated with grease.

J. *High Strength Bolt Holes.*

1. *General.* At the Contractor's option, subject to the condition described in this section, holes may be punched or sub-punched and reamed, drilled or sub-drilled and reamed, or formed by numerically controlled drilling operations.

   The hole for each high strength bolt shall be 1/16 in. (2 mm) larger than the nominal diameter of the bolt less than 1 in. (25 mm) in diameter and 1/8 in. (3 mm) larger for bolts with diameters greater than 1 in. (25 mm).

   In forming any connection, the fabricator may drill holes full size from the solid with all thickness of material assembled in proper position. If the fabricator chooses not to use this method, then these methods apply:

   a. Holes shall be sub-punched or sub-drilled, then reamed full size after assembly in all connections and splices in the main members of trusses, arches, continuous beam spans, bents, towers, plate girders, box girders, and rigid frames.

   b. Holes may be drilled full size unassembled to a steel template for splices of rolled beam stringers that continue over floorbeams or crossframes.

   c. Holes shall be sub-punched and reamed full size to a steel template or reamed full size while assembled for end connections of rolled beam stringers and floorbeams or crossframes.

   If steel templates are used to ream or drill full-size connection holes, the templates shall be positioned and angled with extreme care and bolted firmly in place. Templates for reaming matching members or the opposite faces of one member shall be duplicates. Templates for connections on like parts or members shall be located with such accuracy that match-marks are not needed.

Bolt holes in crossframes, gussets, lateral braces, and other secondary members may be punched or drilled full size from the solid while assembled.

2. *Punched Holes*. For punched holes, die diameter shall not exceed punch diameter by more than 1/16 in. (2 mm). Any hole requiring enlargement to admit the bolt shall be reamed. All holes shall be cut clean with no torn or ragged edges. The State will reject components having poorly matched holes.

   After shop assembly and before reaming, all punched, sub-punched, and sub-drilled holes shall meet the following standard of accuracy. At least 75 percent of the holes in each connection shall permit the passage of a cylindrical pin 1/8 in. (3 mm) smaller in diameter than nominal hole size. This pin shall pass through at right angles to the face of the member without drifting. All holes shall permit passage of a pin 3/16 in. (5 mm) smaller in diameter than nominal hole size. The State will reject any pieces that fail to meet these standards.

3. *Reamed and Drilled Holes.* Reaming and drilling shall be done with twist drills, producing cylindrical holes perpendicular to the member. Reamers and drills shall be directed mechanically, not hand-held. Connecting parts that require reamed or drilled holes shall be assembled and held securely as the holes are formed, then match-marked before disassembly.

   The Contractor shall provide the Engineer a diagram showing these match-marks. The State will reject components having poorly matched holes.

   Burrs on outside surfaces and mating surfaces shall be removed. If the Engineer requires, the Contractor shall disassemble parts to remove burrs.

   At least 85 percent of all holes in a connection of reamed or drilled holes shall show no offset greater than 1/32 in. (1 mm) between adjacent thicknesses of metal. No hole shall have an offset greater than 1/16 in. (2 mm).

   Centerlines from the connection shall be inscribed on the template and holes shall be located from these centerlines. Centerlines shall also be used for accurately locating the template relative to the milled or scribed ends of the members.

   Templates shall have hardened steel bushings inserted into each hole. These bushings may be omitted, however, if the fabricator satisfies the Engineer that:

   a. that the template will be used no more than 5 times; and

   b. that use will produce no template wear.

   Each template shall be at least 1/2 in. (12 mm) thick. If necessary, thicker

templates shall be used to prevent buckling and mis-alignment as holes are formed.

4. *Numerically Controlled Drilled Connections.* In forming any hole described in this subsection, the fabricator may use numerically controlled (N/C) drilling or punching equipment if it meets the requirements in this subsection.

   The Contractor shall submit for approval a detailed outline of proposed N/C procedures. This outline shall:

   a. Cover all steps from initial drilling or punching through check assembly.

   b. Include the specific members of the structure to be drilled or punched, hole sizes, locations of the common index and other reference points, make-up of check assemblies, and all other information needed to describe the process fully.

   N/C holes may be drilled or punched to size through individual pieces, or may be drilled through any combination of tightly clamped pieces.

   When the Engineer requires, the Contractor shall demonstrate that the N/C procedures consistently produces holes and connections meeting the requirements of these Specifications.

5. *Fitting for Bolting.* Before drilling, reaming, and bolting begins, all parts of a member shall be assembled, well pinned, and drawn firmly together. If necessary, assembled pieces shall be taken apart to permit removal of any burrs or shavings produced as the holes are formed. The member shall be free from twists, bends, and other deformation.

   In shop-bolted connections, contacting metal surfaces shall be blast cleaned before assembly. Blasting shall meet the requirements of the SSPC Specifications for Commercial Blast Cleaning (SSPC-SP 6).

   Any drifting done during assembly shall be no more than enough to bring the parts into place. Drifting shall not enlarge the holes or distort the metal.

K. *Assembly.*

1. *Progressive Truss or Girder Assembly.* Unless the contract plans state otherwise, the Contractor shall use progressive truss or girder assembly methods as described below. The Contractor shall obtain the Engineer's approval of both the shop assembly and the erection methods before work begins.

Each truss or girder is assembled in stages over the full length of the superstructure.

a. For trusses. The first stage shall include at least three contiguous panels.

b. For girders. The first stage shall include at least three contiguous shop sections.

After stage one has been completed, each next stage shall be assembled to include at least one panel or shop section of the previous stage, repositioned, if necessary, and pinned to ensure accurate alignment; and two or more panels or shop sections added at the advancing end.

If the bridge is longer than 147.64 ft. (45 m), each stage shall be at least 147.64 ft. (45 m) long, regardless of the length of individual continuous panels or shop sections.

The Contractor shall perform the assembly sequence in the same order as the structure will be assembled in the field.

2. *Check of Shop Assembly.* The Contractor shall check each assembly for alignment, accuracy of holes, fit of milled joints, and other assembly techniques. Drilling or reaming shall not begin until the Engineer has given approval. If the Contractor uses N/C drilling, this approval must be obtained before the assembly or stage is dismantled.

3. *Blasting Cleaning.* For painted structures after fabrication, the Contractor shall blast clean all structural steel (except machine-finished surfaces) to a "near white" finish in accordance with the Steel Structures Painting Council SSPC-SP10. The "near white" surface is shown in the pictorial standards of SSPC-Vis 1-67T as A Sa 2.5 and C Sc 22.5. After blasting and before painting, the Contractor shall remove all loose dust and dirt that remains on the steel. Acid shall not be used to remove scale or stains.

For unpainted weathering steel structures, after fabrication, all steel surfaces, except those to be embedded in concrete, shall be blast cleaned in the shop in accordance with SSPC Specification for Commercial Blast Cleaning (SSPC-SP-6). The blasted appearance shall be equal to, or better than, BSa2 as shown in the pictorial standards of SSPC-VIS 1-89.

For blast cleaning after erection, refer to Subsection 504.03-N, *Erection,* (4.b). For blast cleaning faying surfaces, refer to Subsection 504.03 –L, *Bolted Connections* (1) and Subsection 504.03 –J, *Fitting for Bolting*(5.).

Also refer to 504.03 - N *Erection,* (4.) in this specification.

L. *Bolted Connections.*

1. *General.* All high strength bolted connections are slip critical unless specified otherwise. Painted structures require Type 1 or Type 2 bolts. Unpainted structures require Type 3 bolts. Direct tension indicators shall be mechanically galvanized on painted structures, and mechanically galvanized and epoxy-coated on unpainted structures.

   Bolts, nuts, hardened washers, and direct tension indicators shall be as specified in Subsection 708.06 Bolts.

   The Contractor shall clean all metal surfaces prior to fitting and bolting of the connection. When assembled, all joint surfaces, including surfaces adjacent to the bolt head and nut, shall be free of all dirt, road oil, and other foreign material. When splices are designated Class B, slip-critical, on the plans, the contact surfaces of splices shall be field inspected immediately prior to assembly to ensure that the surfaces are free of all mill scale, dirt, road oil, and other foreign material.

   Burrs that would prevent solid seating of the connected parts in the snug tight condition shall be removed.

   Paint is not permitted on the faying surfaces of slip-critical connections. On faying surfaces of slip-critical connections, paint, including any inadvertent overspray, shall be excluded from areas closer than one bolt diameter, but not less than 1 in. (25 mm) from the edge of any hole and all areas within bolt pattern.

   All material within the grip of the bolt shall be steel. There shall be no compressible material such as gaskets or insulation within the grip. Bolted steel parts shall fit solidly together after the bolts are tightened, and may be coated or non-coated. The slope of the surfaces of parts in contact with the bolt head or nut shall not exceed 1:20 with respect to a plane normal to the bolt axis.

   Fasteners shall be protected from dirt and moisture at the job site. Only as many fasteners as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. Fasteners not used shall be returned to protected storage at the end of the shift. Fasteners shall not be cleaned of lubricant that is present in as-delivered condition. Fasteners for slip critical connections which accumulate rust or dirt resulting from job site conditions, shall be cleaned and re-lubricated prior to installation.

A tension measuring device (a Skidmore-Wihelm calibrator or other acceptable bolt tension indicating device) shall be at all job sites where bolts in slip-critical joints or connections subject to direct tension are being installed and tightened. The tension measuring device shall be used to confirm:

a. the suitability to satisfy the requirements of Table 2 of the complete fastener assembly, including lubrication if required, to be used in the work;

b. calibration of the wrenches, if applicable;

c. the understanding and proper use of the method to be used by the bolting crew.

The frequency of confirmation testing, the number of tests to be performed and the test procedure shall be as specified in the remainder of this subsection. The accuracy of the tension measuring device shall be confirmed through calibration by an approved testing agency at least annually.

All bolting and testing operations shall be inspected by the Engineer in order to determine that the approved installation procedure is utilized and that the correct tension has been achieved. All testing operations completed without the presence of the Engineer shall be cause for rejection.

All high strength bolts, nuts, washers, and DTIs shall be stored under cover to protect them from rain, snow, dirt or other adverse conditions. Identification of heat number or production lot number shall remain with each type of bolting parts. Any bolting parts that are rusty, dirty, or have damaged threads shall not be accepted.

Before bolts are installed they shall be subject to a job site rotational-capacity test. The rotational capacity test shall be performed on each rotational-capacity lot. The test shall also be done if the bolts are installed in the shop. Hardened steel washers are required as part of the test although they may not be required in the actual installation procedure.

Bolt, nut, washer and DTI (when required) combinations as installed shall be from the same rotational-capacity lot.

The rotational-capacity test shall be done according to Section 708.06 Bolts Subsection 2.A.(4)

Nuts shall be located, wherever practicable, on the side of the member,

which will not be visible from the traveled way. Nuts for bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete.

The nut shall be turned tight while the bolt is prevented from rotating. Each bolt shall have a hardened washer under the nut. If the Engineer approves, the Contractor may reuse any M 164 bolt one time. Re-tightening a bolt loosened by the tightening of nearby bolts will not be considered reuse.

To begin bolting any connection, the Contractor shall install and tighten to snug-tight enough bolts to bring all parts into full contact with each other. "Snug-tight" means either the tightness reached by (1) a few blows from an impact wrench, or (2) the full effort of a man using a spud wrench.

After this initial tightening, bolts shall be installed and brought to snug-tight in all holes that remain in the connection. Then, beginning with bolts in the most rigid part of the joint and working out to its free edges, the Contractor shall systematically tighten all bolts to specified tension.

When all bolts in a joint are tight, each bolt shall carry at least the proof load shown in Table 2.

TABLE 2
BOLT TENSION

English Units

	Minimum Bolt Tension (lbs.)	
Bolt Size in.	AASHTO M 164 ASTM A325	AASHTO M 253 ASTM A490
0.5	12,050	14,900
0.625	19,200	23,700
0.75	28,400	35,100
0.875	39,250	48,500
1.0	51,500	63,600
1.125	56,450	80,100
1.25	71,700	101,800
1.375	85,450	121,300
1.5	104,000	142,500

SI Units

	Minimum Bolt Tension (kN)	
Bolt Size	AASHTO M 164M	AASHTO M 253M

(mm)

(16)	(91)	(114)
(20)	(142)	(179)
(22)	(176)	(221)
(24)	(205)	(257)
(27)	(267)	(334)
(30)	(326)	(408)
(36)	(475)	(595)

2. *Tightening Methods*. Unless otherwise shown on the plans, tightening shall be done by the direct-tension-indicator method.

   a. Direct Tension Indicator Tightening (DTI).

      (1) Installation. The Direct Tension Indicator (DTI) shall be located at the opposite end of the bolt from the part being tightened where possible. When the DTI is used next to a slotted or oversized hole, a hardened flat washer shall be placed between the DTI and the part being tightened; the DTI shall not be reused after tension has been applied to the bolt.

      (2) Bolt Tension. Bolt tension shall be in accordance with ASTM F959 and the following:

         (a) The gap for mechanically galvanized epoxy coated DTIs shall be measured at 0.005 in. (0.125 mm) or less. A nil gap condition may be cause for rejection. The Engineer may require any bolt with nil gap to be removed from the work and the bolt thread examined at no additional cost. If no necking is observed and the nut can run down the full length of the thread, then the bolt can be reinstalled with new DTIs.

         (b) Verification of DTI performance is required prior to the starting of installation of bolts in the bridge. The testing procedure shall be done in accordance with Procedure for Verification and Installation of High Strength Bolts with Direct Tension Indicators. This procedure is in Appendix A6 of Report No. FHWA-SA-91-031 dated May 1991, revised April 1992.

   b. Turn-of-Nut Method. After all bolts in the joint have been brought to snug tightness, the nuts shall be further tightened by the amount of rotation shown in Table 3.

After snug tightening, but before final tightening, the Contractor shall match-mark with crayon or paint the outer face of each nut and the protruding part of the bolt. To ensure that this tightening method is followed, the Engineer will:

(1) observe as the Contractor installs and tightens all bolts; and

(2) inspect each match-mark.

Three bolts of the same grade, size, and condition as those under inspections shall be placed individually in a device calibrated to measure bolt tension. This calibration operation shall be done at least once each inspection day. There shall be a washer under the part turned in tightening each bolt if washers are used on the structure. If washers are not used on the structure, the material abutting the part turned shall be of the same specification as that used on the structure. In the calibrated device, each bolt shall be tightened by any convenient means to the specified tension. The inspecting wrench shall then be applied to the tightened bolt to determine the torque required to turn the nut or head 5° or approximately 1 in. at a 12 in. radius (25 mm at a 300 mm radius) in the tightening direction. The average of the torque required for all three bolts shall be taken as the job-inspection torque.

The Contractor, in the presence of the Engineer, shall inspect the tightened bolt using an inspection torque wrench.

Ten percent (at least two) of the tightened bolts on the structure represented by the test bolts shall be selected at random in each connection. The job-inspection torque shall then be applied to each with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the State will accept the connection as being properly tightened, but if the torque turns one or more bolt heads or nuts, the job-inspection torque shall then be applied to all bolts in the connection. Any bolt whose head or nut turns at this stage shall be tightened and re-inspected. The Contractor may, however, retighten all the bolts in the connection and resubmit it for inspection.

TABLE 3
TURN-OF-NUT TIGHTENING METHOD

Nut Rotation[1] from Snug-Tight Condition

Bolt Length l (Measured from	**(Both faces at right angles to bolt axis)**	**(One face at right angle to bolt axis,**	**(Both faces sloped no more than 1:20**

underside of head to extreme end of point) washer)		**one face sloped no more than 1:20, without bevel**	**from right angle to bolt axis, without bevel washer)**
$l \leq 4D$	120º or 1/3 turn	180º or 1/2 turn	240º or 2/3 turn
$4D \leq 8D$	180º or 1/2 turn	240º or 2/3 turn	300º or 5/6 turn
$8D \leq 12D$ [3]	240º or 2/3 turn	300º or 5/6 turn	360º or 1 turn

[1] Nut rotation is relative to the bolt regardless of which element (nut or bolt) is being turned. Tolerances permitted: plus or minus 30º for final turns of 180º - 1/2 turn or less; plus or minus 45º for final turns of 240º - 2/3 turn or more.

[2] D = nominal bolt diameter of bolt being tightened.

[3] When bolt length exceeds 12D, the rotation shall be determined by actual tests in which a suitable tension device simulates actual conditions.

M. *Welding.*

1. *General.* Welded fabrication shall be in accordance with ANSI/ AASHTO/ AWS D1.5 Bridge Welding Code and all Interim Revisions published by AASHTO as of the bid opening date except as modified in the remainder of the subsection or as shown on the plans.

   Welding of tubular members shall conform to the current addition of AWS D1.1 Structural Welding Code-Steel.

   Welding of sheet steel not exceeding 1/8 in. (3 mm) in thickness shall conform to the current addition of AWS D1.3 Structural Welding Code-Sheet Steel.

   Welding of aluminum shall conform to the current addition of AWS D1.2 Structural Welding Code-Aluminum.

   Welding of structural steel will be permitted only to the extent shown in the plans. No welding, including tack and temporary welding, shall be done in the shop or field unless the location of the welds is shown on the approved shop drawings or approved by the Engineer in writing.

   Welding shall not begin until after the Contractor has received the Engineer's approval of shop plans, as required in Subsection 504.01 – G. *Shop Plans.* These plans shall include procedures for welding, assembly, and any heat-straightening or heat-curving.

2. *Preheating.* Preheat and interpass temperatures shall comply with the minimums

in the table below:

Thickness (t) of Thickest Part at Point of Cutting, in. (mm)		Temperature °F (°C)	
$t \leq .0.75$	$(t \leq 19)$	50	(10)
$0.75 < t \leq 1.5$	$(19 < t \leq 38)$	70	(21)
$1.5 < t \leq 2.5$	$(38 < t \leq 63.5)$	149	(65)
$t > 2.5$	$(t > 63.5)$	225	(107)

The plate shall be preheated in such a manner that the required temperature is obtained through the full thickness of the plate ahead of and laterally from the cut a distance of 3 in. (75 mm) or the plate thickness, whichever is greater.

Preheat temperatures shall be shown on the shop drawings.

All web and flange plates, bearing stiffeners, bearing plates, and heavy sections (restrained when welded) shall be preheated to at least 250°F (120°C).

3. *Welding Procedures.* Unless otherwise approved by the Engineer, welding of main members and welding of attachments thereto shall be performed using only shielded metal arc, submerged arc, and/or stud welding, and all welding of butt splices and flange to web welds shall be done using the automatic submerged arc process using continuous passes without interruption. Flux cored welding may be substituted with prior approval of the Engineer only in areas where automatic submerged arc welding is not feasible. Complete joint penetration groove welds made by flux cored arc welding may be approved only after submittal of performance of the joint qualification test prescribed in Section 5.7 and tested in accordance with Section 5.12 of the ANSI/ AASHTO/ AWS D1.5 Bridge Welding Code. Joint qualification tests shall be performed and submitted on each individual project. The test coupons shall be submitted to an independent testing laboratory for testing. All costs associated with the making of the test coupons and testing of the coupons shall be borne by the Contractor.

   In shielded metal-arc welding, the Contractor shall use low-hydrogen electrodes.

   In submerged-arc welding, flux shall be oven-dried at 550°F (288°C) for at least 2 hours, then stored in ovens held at 248°F (120°C) or more. If not used within 4 hours after removal from a drying or storage oven, flux shall be re-dried before use.

   The Contractor shall not:

   a. weld with gas metal arc, electrogas or electroslag methods;

b. weld when ambient temperature is below 20°F (-7°C); or

c. use coped holes in the web for welding butt splices in the flanges unless the plans show them.

Tack welds shall only be placed so that they are incorporated into the final weld and shall be subject to the same quality requirements as the final welds except that discontinuities such as undercut, unfilled craters, and porosity need not be removed before the final submerged arc welds. Tack welds shall be made with electrodes meeting the requirements of the final welds and shall be cleaned thoroughly. Multiple-pass tack welds shall have cascaded ends.

If groove welds (web-to-web or flange-to-flange) have been rejected, they may be repaired no more than twice. If a third failure occurs, the Contractor shall:

a. trim the members, if the Engineer approves, at least 1/2 in. (13 mm); or

b. replace the members at no expense to the State.

Welds shall be terminated at the end of the joint in a manner that will ensure sound welds. Whenever possible, this shall be done by the use of extension bars and runoff plates configured to duplicate the joint detail being welded. Extension bars and runoff plates shall be removed upon completion and cooling of the weld, and the ends of the welds shall be ground smooth and flush to minimum surface finish of ANSI 125. The ends of all groove welds shall be 100 percent inspected using dye penetrant or magnetic particle testing techniques. These shall include but not be limited to splices in individual flanges and webs, transverse and longitudinal stiffeners, floorbeams, and stringers.

Arc strikes outside the weld joint, on metal that will not be incorporated in a weld joint, may be cause for rejection of a member. All arc strikes on surfaces carrying tensile or reversal stress shall be reported in writing to the Engineer. Arc strikes on surfaces carrying tensile or reversal stress shall not be repaired without written authorization from the Engineer. Repair of arc strikes shall be accomplished by grinding the area containing the arc strike to a minimum surface finish of ANSI 125. The ground area shall be inspected by the dye-penetrate method and tested for heat-affected-zone hardness. If the testing specified above reveals cracking and/or hardness in excess of Rockwell C23, the area shall be weld repaired under the provisions of ANSI/ AASHTO/ AWS D1.5 Bridge Welding Code.

4. *Fillers.* All filler metal utilized for welding of unpainted AASHTO M270M, Grade 345W (M270, Grade 50W), bridge steel shall conform to the requirements of Table 4.3 of the current AWS Specifications.

When a bolted splice is used to join plates of differing thickness, filler plates used to compensate for the thickness difference shall not be welded into place unless approved in writing.

5. *Shear Connectors.* Shear connectors shall be shop welded using automatically timed stud welding equipment unless approved in writing by the Engineer.

   Any welded shear connector longer than 8 in. (200 mm) may be made of two shorter shear connectors joined with full-penetration welds.

6. *Welding Inspection.* The Contractor's welding inspection procedures, techniques, and inspector qualification shall comply with Current ANSI/ AASHTO/ AWS D1.5 Bridge Welding Code except as modified in the remainder of this subsection or as shown on the plans.

   Certified welding inspectors shall inspect all welds using these methods:

   a. Visual Inspection. Every weld shall be given a 100 percent visual inspection.

   b. Radiographic Inspection. Full-penetration groove welds subject to tension or reversal shall be given a 100 percent radiographic inspection. These welds include those in the tension area of webs, where inspection shall cover the greater of these two distances: (1) 15 in. (380 mm) from the tension flange, or (2) one-third of the web depth from the tension flange.

   c. Magnetic Particle Inspection. Fillet welds, and longitudinal butt welds in webs shall be given a magnetic particle inspection. Magnetic particle test shall use the yoke method only.

      (1) Flange-to-Web Connections. Until the Engineer accepts the Contractor's record of quality control, 100 percent of all fillet welds in flange-to-web connections of built up members shall be inspected. After such acceptance, 30 percent of each weld shall be inspected. Ten percent of this inspection shall occur at each end of the welds length. The remaining 10 percent shall occur randomly at points selected by the Engineer.

      (2) Boxed Members of Trusses. Each fillet weld in boxed members of trusses shall be given a 100 percent inspection.

      (3) End and Intermediate Pier Diaphragms. Each fillet weld in end and intermediate pier diaphragms shall be given a 100 percent inspection.

(4) Longitudinal Butt Weld in Web. Each longitudinal butt weld in the web shall be inspected under the same requirements as flange-to-web connections (see above).

(5) Stiffeners and Connection Plates. Thirty percent of each fillet weld in transverse and longitudinal web stiffeners and connection plates shall be inspected. Ten percent of this inspection shall occur at each end of the weld. The remaining 10 percent shall occur randomly at points selected by the Engineer.

(6) Miscellaneous Weldments. Each fillet weld in miscellaneous weldments (such as bridge bearing assemblies) shall be given a 100 percent inspection.

d. Ultrasonic Inspection. All full-penetration groove welds shall be ultrasonically inspected.

(1) Transverse Flange and Web Splices. Each transverse groove weld on flange and web splices shall be given a 100 percent inspection.

(2) End and Intermediate Pier Diaphragms. Each groove weld on end and intermediate pier diaphragms shall be given a 100 percent inspection.

(3) Other Weldments. Each groove weld in other weldments shall be given a 100 percent inspection, unless the plans state otherwise.

e. Dye-Penetrant or Magnetic-Particle Inspection. The end of each groove weld at plate edges shall be given a 100 percent dye-penetrant or magnetic-particle inspection.

f. Other Inspection. The Contractor shall perform all additional testing as shown on the plans.

N. *Erection.*

1. *Erection Marks.* Erection marks to permit identification of members in the field may be painted on surfaces to be painted in the field. For unpainted AASHTO M270M, Grade 345W (M270 Grade 50W), erection marks shall be stamped with low stress intermittent dot steel die stamp in an area visible after completion of the structure. The maximum allowable depth of the impression shall be 0.010 in. (0.25 mm) and the tool shall conform with the following requirements:

Character Size in. (mm)	Minimum Character Face Radius in. (mm)

1/8	(3)	0.007	(0.175)
3/16	(5)	0.008	(0.200)
1/4	(6)	0.010	(0.250)

Impressions shall not be near the edge of tensile-stressed plate members.

2. *Alignment and Camber.* Before beginning field bolting, the Contractor shall:

   a. adjust the structure to correct grade and alignment;

   b. regulate elevations of panel points (ends of floorbeams); and

   c. delay bolting at compression joints until adjusting the blocking to provide full and even bearing over the whole joint.

   On truss spans, a slight excess camber will be permitted as the bottom chords are bolted. But camber and relative elevations of panel points shall be correct before the top chord joints, top lateral system, and sway braces are bolted.

   The Contractor shall provide the Engineer with a diagram for each truss that shows camber at each panel point. This diagram shall display actual measurements taken as the truss is being assembled.

3. *Field Assembling and Bolting*. To begin bolting any field connection or splice, the Contractor shall install and tighten to snug-tight, enough bolts to bring all parts into full contact with each other prior to tightening these bolts to the specified minimum tension. "Snug-tight" means either the tightness reached by (1) a few blows from an impact wrench or (2) the full effort of a person using a spud wrench.

   Bolting a field connection shall be completed using one of the following methods:

   a. *Method A*. As erection proceeds, all field connections and splices for each member shall be securely drift pinned and bolted in accordance with 1 or 2 below before the mass of the member can be released or the next member is added. Field erection drawings shall specify pinning and bolting requirements that meet or exceed the following minimums:

      (1) Joints in Normal Structures. Fifty percent of the holes in a single field connection and fifty percent of the holes on each side of a single joint in a splice plate shall be filled with drift pins and bolts. Thirty percent of the filled holes shall be pinned. Seventy percent of the filled holes shall be bolted and tightened to snug-tight. Once all these bolts are snug-tight,

each bolt shall be systematically tightened to the specified minimum tension. "Systematically tightened" means beginning with bolts in the most rigid part, which is usually the center of the joint, and working out to its free edges. The fully tensioned bolts shall be located near the middle of a single field connection or a single splice plate.

(2) Joints in Cantilevered Structures. Seventy-five percent of the holes in a single field connection and 75 percent of the holes on each side of a single joint in a splice plate shall be filled with drift pins and bolts. Fifty percent of the filled holes shall be pinned. Fifty percent of the filled holes shall be bolted and tightened to snug-tight. Once all these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. The fully tensioned bolts shall be located near the middle of a single field connection or a single splice plate. A joint in a cantilevered structure shall be defined as a field connection or splice that is on the unsupported or cantilevered side of a support. Joints that fit this description in either their final position or temporary position (during erection) shall be considered as joints in cantilevered structures.

Drift pins shall be placed throughout each field connection and each field joint with the greatest concentration in the outer edges of a splice plate or member being bolted.

To complete a joint, the Contractor shall fill all remaining holes of the field connection or splice plate with bolts and tighten to snug-tight. Once all of these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. After these bolts are tightened to the specified minimum tension, the Contractor shall replace the drift pins with bolts, tightened to the specified minimum tension.

b. *Method B*. The Contractor may complete a field bolted connection or splice in a continuous operation before releasing the mass of the member or adding the next member. The Contractor shall utilize drift pins to align the connection. The alignment drift pins shall fill between 15 and 30 percent of the holes in a single field connection and between 15 and 30 percent of the holes on each side of a single joint in a splice plate. Once the alignment drift pins are in place, all remaining holes shall be filled with bolts and tightened to snug-tight starting from near the middle and proceeding toward the outer gage lines. Once all of these bolts are snug-tight, the Contractor shall systematically tighten all these bolts to the specified minimum tension. The Contractor shall then replace the drift pins with bolts. Each of these bolts shall be tightened to the specified minimum tension.

All bolts shall be placed with heads toward the outside and underside of the

bridge. All high-strength bolts shall be installed and tightened before the falsework is removed.

The Contractor may erect metal railings as erection proceeds, but railings shall not be bolted or adjusted permanently until the falsework is released and the deck placed.

The Contractor shall not begin painting until the Engineer has inspected and accepted field bolting.

4. *Surface Condition.* As the structure is erected, the Contractor shall keep all steel surfaces clean and free from dirt, concrete, mortar, oil, paint, grease, and other stain-producing foreign matter. Any surfaces that become stained shall be cleaned as follows:

   a. Painted steel surfaces shall be cleaned by methods required for the type of staining. The method shall be submitted to the Engineer for approval.

   b. Weathering steel surfaces. After the deck is placed, all concrete stains and other foreign matter shall be removed from the exposed surfaces of all structural steel members by power cleaning or other approved method. This cleaning is necessary to provide a surface for the formation of patina (oxide coating) which will give long term protection to the steel.

504.04 Method of Measurement

Structural metals will be measured by the pound (kilogram), foot (meter), or on a lump sum basis. Where payment is on a weight basis, the weights of rolled shapes and of structural steel plates shall be computed on the basis of their nominal weights and dimensions.

Steel forgings will be measured by the pound (kilogram) based on the plan dimensions and the theoretical weight of 0.2833 lb./in.^{3} (7842 kg/m^3).

Structural steel handrail, two tube curb mount rail, pedestrian/bicycle railing, and combination pedestrian/bicycle railing will be measured by the foot (meter), complete in place.

504.05 Basis of Payment

Payment will be made on "plan quantities" as specified in Subsection 109.01.

Payment for accepted work will be made as follows:

Pay Item	Pay Unit
Steel Bridge	L. S.
Structural Steel	lb. (kg) or L. S.
Steel Forgings	lb. (kg)
Structural Steel Handrail	ft. (m)
Two Tube Curb Mount Rail	ft. (m)
Pedestrian/Bicycle Railing	ft. (m)
Combination Pedestrian/Bicycle and Traffic Railing	ft. (m)